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Surprising Science for Kids:

Engineering Design

KIT-560

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Welcome to
Surprising Science for Kids:
Engineering Design
Grades 5 - 8

Your **Surprising Science for Kids: Engineering Design** kit includes almost everything you need to perform six hands-on experiments and dynamic demonstrations related to engineering design. The perfect starting point for aspiring engineers!

Included in this kit:

- 24 Jumbo Craft Sticks
- Cardboard
- Fishing Line
- Skewer
- Push Pin
- Hot Glue Gun
- 3 Extra Hot Glue Sticks
- Colored Duct Tape
- Ruler
- Propeller
- 3 Rubber Bands
- 2 Large Paper Clips
- 12 Popsicle Sticks
- Helicopter Pattern
- 2 Syringes
- Clear Tubing
- 2 Large Clear Straws
- Small Cup
- Dye Tablets
- Black Electrical Tape
- Pipe Cleaner
- Paper Plate
- Plastic Glove
- 2 Black Paper Straws
- String
- Wood Accessories for the Eccentric Wheel
- Sand Stick
- Glue

You will also need:

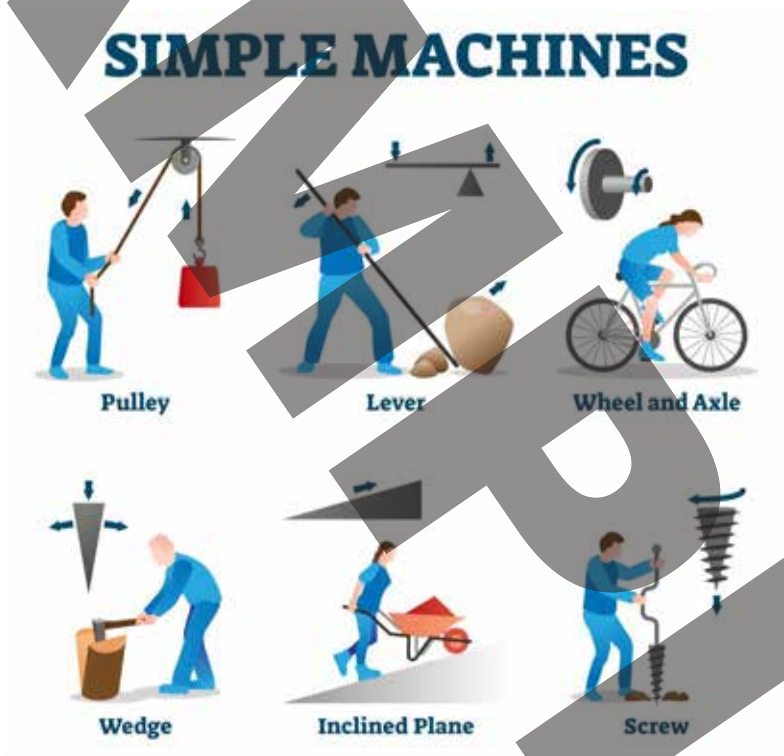
- Scissors
- Water
- Pen / Pencil

Introduction

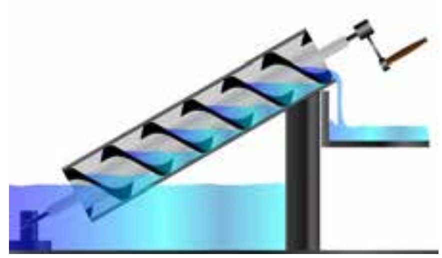
Have you ever thought to yourself, what's so important about learning science and math? The answer is because they are used to solve real-life problems.

As civilizations evolved, one of the most important advancements came from their ability to design and build things that made life easier and more comfortable for their citizens. Whether it was constructing shelters or places to live, pathways, roadways or bridges to travel from one area to another, or building simple or complex machines to make their work easier, the societies with the best engineering designs were the most successful, and their citizens lived better lives.

In a practical sense, engineering has existed since ancient times, when humans devised instruments now called **simple machines** such as the wedge, lever, and wheel and axle to help them reduce their effort when having to do work such as moving or lifting things.



Over time, these simple machines evolved into more complex machines. For example, the Archimedes screw was designed to move water from a lower elevation to a higher elevation.



Introduction

continued

Today our machines have become much more complex, but all are based on the original simple machines.

The profession we now call engineering officially came about more than 700 years ago when specialists began using mathematics to design military fortresses. These special designers would typically have craftsmen complete the actual construction. So, technically, they became the first real engineers in the modern sense of the word.

Leonardo da Vinci

Activity 1:
The da Vinci Bridge

One of the earliest engineers was Leonardo da Vinci (1452–1519). You may recognize him as the artist who painted the Mona Lisa and The Last Supper, but da Vinci was more than just a painter. He was well ahead of his time with his conceptual designs, many of which are in use today.

From a young age, da Vinci was very curious. As he grew, he developed a wide range of skills. This gave him the tools he needed to create designs for everything from flying machines and machine guns to parachutes and scuba gear.

Back in 1502, da Vinci designed a 280-meter-long bridge that was intended to connect Istanbul with a neighboring city, Galata. Though he didn't actually get the opportunity to construct the bridge, his design was far different than the classic models. His structure was intended to stand on its own, using the force of gravity instead of any fasteners or mortar, to hold the stone together.

In this activity, you will build a small version of his famous bridge.

Vocabulary:

Tension: The force that pulls things apart.

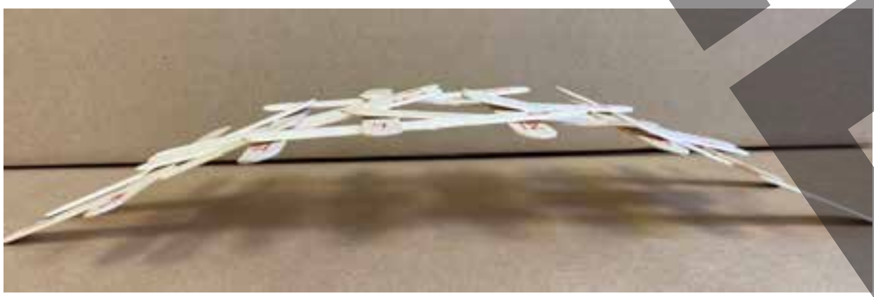
Compression: The force that pushes things together.

Materials:

- 18 Jumbo Craft Sticks

Your challenge is to build a bridge using 18 craft sticks. The bridge will stand on its own using only the craft sticks. After you weave the sticks together, the tension of the sticks will support the structure and lift it off the surface of the table. This bridge design should withstand downward forces, but any forces from the side will cause it to topple. You'll need some patience for this project, so if it falls apart, start back at the beginning and try it again!

Feel free to try this on your own. If you need additional help, see the instructions on the next pages.



Activity 2:
Tensegrity Structure

Tensegrity is short for tensional integrity. This term was made up by Buckminster Fuller, an American engineer, architect, designer, inventor, and all-around clever guy. This word is used to describe a structure whose form relies on both tension and compression.

As we learned in the last activity, a **tension force** is one that pulls materials apart whereas a **compression force** pushes materials together. Some objects, like a rope, can support a great deal of tension. But it can't resist compression. This is why you can use a rope to play tug-of-war, but if you try to compress a rope, it will simply bend.

Materials:

- Cardboard
- Skewer
- Duct Tape
- Scissors (not included)
- Fishing Line
- Push Pin
- Rubber Band
- Paper Clip
- Hot Glue Gun
- Ruler

Take a look at the image below and try to figure out how the floating table actually works. The surface of the table is being held up by the string that is attached to the wooden skewer, and then it's kept stable by the three support lines attached to its edges.

Activity 2:
Tensegrity Structure
continued

20. Glue the "wings" of the top support piece to the top piece as shown.

21. Cut two base pieces and glue them together.

22. Cut twelve brace pieces and glue six pieces together to make two large braces.

23. Glue the brace assemblies to the top support to make it sturdier as shown.

24. Draw a face on your character.

25. Cut a piece of the clear fishing line so it is 5 inches long.

26. Thread it through the hole you just made in the support piece. Then loop the line around skewer and tie a knot in the line. The robot and the top piece should now be connected by the fishing line.

27. Cut three 12-inch long pieces of fishing line and then tape each to the top in the positions as shown in the photo using the duct tape provided.

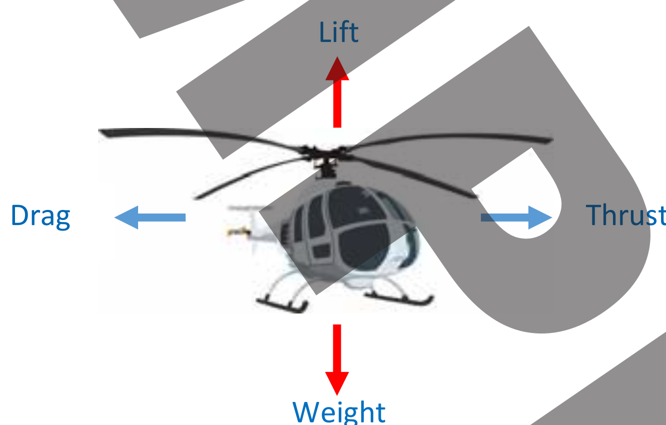
Activity 3:
Whirly Bird

Leonardo da Vinci's Aerial Screw was one of the earliest designs for a helicopter-like flying machine. As it was, this device wasn't actually capable of flight, but da Vinci was certainly on the right track!

Although a number of inventors designed relatively successful vertical flying machines, it wasn't until 1939 that the first mass produced helicopter actually lifted into the air. Built by Igor Sikorski, a Russian-born American citizen, these helicopters played a significant role in World War II. Today, Sikorski helicopters are among the most well-known in the industry.

Today, when you see airplanes and helicopters flying overhead, you may think that creating them must be an easy process. The reality is that any time you have a flying machine, a great deal of science, mathematics, engineering, and imagination had to go into the planning, design, and building.

Basically, four forces act on airplanes and helicopters in flight. Lift and weight work in opposition, as do thrust and drag. Lift, the force produced by the rotor blades to carry the craft aloft, is directly counteracted by the force of weight. This is caused by Earth's gravitational pull downward.



Thrust, the force produced by the rotor to move the craft forward, is in direct opposition to drag, the force caused by air friction, which slows the craft. The more aerodynamic the machine is, the less drag is produced.

So, when aeronautical engineers design a helicopter, they need to build one that's light enough so the rotor blades can lift it and propel it forward, and it must be smooth and sleek with no rough surfaces creating friction and drag.

In addition to reducing the negative forces, engineers need to deal with torque, the twisting force that causes an object to rotate around an axis. For example, if we have a propeller on a motor, as the propeller spins one way the motor wants to spin in the opposite direction. Because of this, engineers need to design their aircraft to counteract torque.

Activity 4:
Hydraulic Lift

Hydraulics is a branch of science that deals with forces and motion related to liquids. Hydraulic systems work by using pressurized fluids to transfer a force from one area to another. Unlike gases, liquids cannot be compressed, so they are commonly used in hydraulic machines like elevators, backhoes, and brakes to name a few.

Materials:

- 2 Syringes
- Small Cup
- 4 Large Craft Sticks
- Pipe Cleaner
- Water (not included)
- Clear Tubing
- 2 Dye Tablets
- Colored Duct Tape
- 2 Clear Straws
- Hot Glue Gun
- 11 Popsicle Sticks
- Black Electrical Tape
- Ruler

Instructions:

1. Find the syringes and the clear tube in your kit. Pull the plunger back on one, to the 10 ml mark. On the other, fully press the plunger so there is no air in it. Attach the two syringes to the tubing as shown.

Activity 4:
Hydraulic Lift
continued

15. Then, using some duct tape, first secure the larger craft stick that is attached to the structure to another craft stick to act as an arm. The tape should provide a hinge so the upper stick can bend downward. Using about 5 cm of black electrical tape, attach the syringe to the lower craft stick so that the upper arm rests on the top of the syringe at its lowest point.

16. Cut the pipe cleaner in half. Wrap the pipe cleaner around the upper stick and loop it around the plunger of the syringe. Test the lift by pushing the syringe that is not attached so the attached syringe fills with water. Then pull back on the syringe to lower the lift.

17. Glue two more large craft sticks onto the arm of the lift to extend the lift.

18. Now, loop the other half of the pipe cleaner and using the black electrical tape, attach the now empty cup on opposite sides like a basket handle. Finally, attach the pipe cleaner to the arm of the lift. Put an item in the basket and raise and lower it using the hydraulic lift!

What is the function of the two additional craft sticks you added to the front base of the lift?

___

___

Is there something else you can build using hydraulics?

Activity 5:
Build an Artificial Hand

continued

5. Cut pieces of the paper straw to fit between the joints of each finger. Because the bones of your fingers are different sizes depending upon the finger, the straw pieces will be different sizes.

6. Glue one piece of straw on either side of each joint where you bone would be.

7. Cut five more pieces of straw ½ inch in length and glue them across the palm where you drew the line that connects the pinkie and the thumb. Be sure to leave a little space between each piece of straw.

8. Cut your string into five 8” pieces. Thread a piece of string through each straw piece on the pinkie finger and through the first straw nearest the pinkie on the palm of the hand.

9. Using the hot glue gun, attach the string at the back tip of the pinkie finger.

10. Repeat with the four other fingers.

11. Test it out! Pull gently on each string to make sure that finger works.

Activity 6:
The Eccentric Wheel

An axle is a post or shaft that a wheel rotates on. An eccentric wheel is similar to a regular wheel except that there is an axle on the wheel that is off center. This makes the wheel rotate in a non-circular manner. The word **eccentric** means unconventional or slightly strange, so when you see a wheel with an axle in the center, it looks normal, but having an axle attached to the edge of the wheel looks rather strange.

When you have an axle that is off center, it creates an unusual movement. Engineers use eccentric wheels for things like car pistons, locomotives, oil rigs, and amusement park rides.

In this activity, you will use three wheels whose axle hole is on the edge of the disk. When these wheels are mounted on an axle, the outer edge of the disk pushes on another mechanism to produce a repeating motion. This motion creates dancing heads.

Activity 6:
The Eccentric Wheel

continued

7. Then slide the smiling heads through the top holes of piece 5. Attach part 9 to the bottom of the smiling heads.

8. Attach part 10 to the solid end of piece 11 and then thread through the hole on part 4. At this point, the eccentric wheels (part 6) should be dry. Slide them onto part 11 so that the wheels are pointing in opposite directions.

9. Slide the split end of piece 11 through the hole on the other side. Using the second piece 11, slide through the opposite hole so the axle (piece 11) forms a +. Push all the way through so the ends are flush (even with one another).

10. Move the eccentric wheels so they are directly below the circles (part 9) at the bottom of the smiling heads.

11. Attach the peg (handle) to the wheel (part 10).